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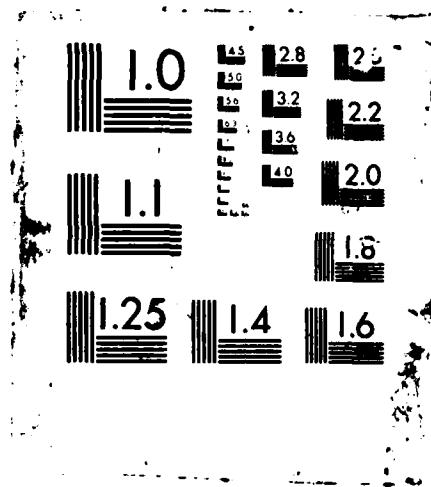
COMPARATIVE TRACTIVE PERFORMANCE OF MICROSPIPED AND  
CONVENTIONAL RADIAL TIRE DESIGNS (U) COLD REGIONS

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US Army Corps  
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Cold Regions Research &  
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# *Comparative tractive performance of microsiped and conventional radial tire designs*

George L. Bladell and Terry L. Morrison

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The braking and driving tractive effectiveness of aftermarket microsiping of all-season design radial tires was studied as an alternative to standard traction aids such as snow tires, studs, and chains. Microsiping is a process that involves laterally slicing the tires to a depth close to that of the tread depth, thus dividing each tread element into several adjacent, contacting elements. Microsiping removes virtually no material from the tire. From previous studies, it is known that traction on ice is overwhelmingly dependent on the adhesion between the ice surface and the tire tread compound. Since microsiping does not alter the compound, a measurable improvement in traction on ice for several tire types and temperatures, as expected, was not found.			
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## PREFACE

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## COMPARATIVE TRACTIVE PERFORMANCE OF MICROSIPED AND CONVENTIONAL RADIAL DESIGN TIRES

George L. Blaisdell  
Terry L. Rogers

### INTRODUCTION

There are several options available to motorists who seek to improve the tractive capability of their vehicles, whether for snow, ice, or just wet pavement driving. The most obvious, though often most costly and time-consuming to implement, is simply to install different tires that supposedly produce greater tractive force than the original tires on the vehicle. Other methods of improving tractive capability involve the use of any of a number of attachable/detachable traction aids. These include link, reinforced link, and cable chains as well as many varieties of chains that may be made of steel, elastomeric materials, or plastics. Yet another type of traction aid are tire studs, which, unlike chains, are not quickly installed or removed. The average motorist must rely on a service garage or other business for installation of tire studs, and in addition, the majority of tires are not even manufactured to allow stud installation.

These methods of improving traction -- different tires, chains, and studs -- have all been studied in the past, particularly by the NSC's Committee on Winter Driving Hazards (various reports, 1968-1983). However, a method that is also claimed to improve traction and that has received relatively little attention in the recent past is the microsiping of conventional tires.

Microsiping is an aftermarket process that is purported to provide an alternative to more aggressive traction aids. The process of microsiping involves the lateral slicing of the tire tread surface to a depth close to that of the tread depth and, unlike siping, removes virtually no material from the tire. Thus, microsiping results in dividing the original tread elements into several adjacent, contacting elements.

In an effort to evaluate the effectiveness of microsiping as a traction aid, a study was conducted during the winter of 1984 to compare the driving and braking performance on ice of microsiped and conventional all-season design radial tires. For this particular study, the tires were sliced with a spacing of two cuts per centimeter (five cuts per inch) at an angle of 85° to the direction of travel. Microsiping of the tires was performed by Marcy Manufacturing Inc., using their Saf-Tee Siper machine.

#### BRAKING TRACTION TESTS

##### Test Area and Equipment

All braking traction tests were performed on a 305 m (1000 ft) by 76 m (250 ft) by 15 cm (6 in.) thick ice sheet in Stevens Point, Wisconsin. The tests were conducted during a one-week period in January 1984. A Dodge Omni was used as the test vehicle for the braking traction tests; it was equipped with alternate sets of new P155/80R13 all-season radial tires at all stations. Test tire inflation pressures were maintained at 220 kPa (32 lb/in.<sup>2</sup>), and the tires were broken in on dry pavement for a distance of 161 km (100 mi) before the tests. The axle loads were 5825 N (1309 lbf) on the front and 3600 N (809 lbf) on the rear. Four different tire types, in both microsiped and conventional configurations, were tested. Their footprints are shown in Figure 1 and Figure 2, respectively.

##### Test Procedure

The test vehicle was driven in a straight line into the test area at a speed slightly greater than 32 km/h (20 mi/h). With the vehicle coasting, the brakes were applied forcefully to begin the test when the test vehicle speed had dropped to 32 km/h (20 mi/h). This resulted in four-wheel, locked-wheel braking. During skidding the vehicle operator attempted to hold the vehicle in its initial, straight-ahead attitude. At the time the brakes were applied, the observer in the vehicle triggered the fifth wheel to record the stopping distance (from the initial brake application point to complete stop). The observer also recorded the 32 km/h (20 mi/h) target speed from the vehicle's speedometer (which had been tested for accuracy relative to the fifth wheel) and any angle of deviation from a straight

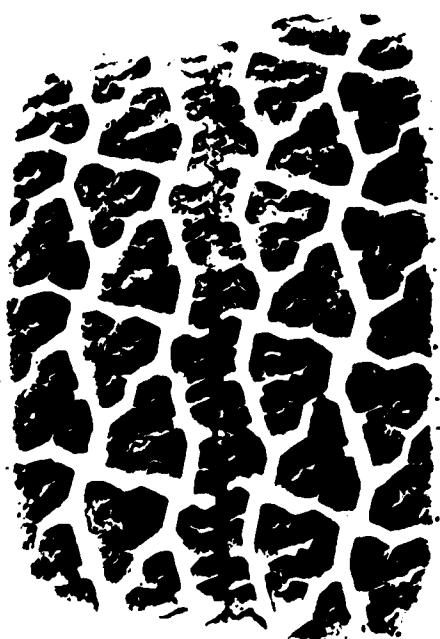
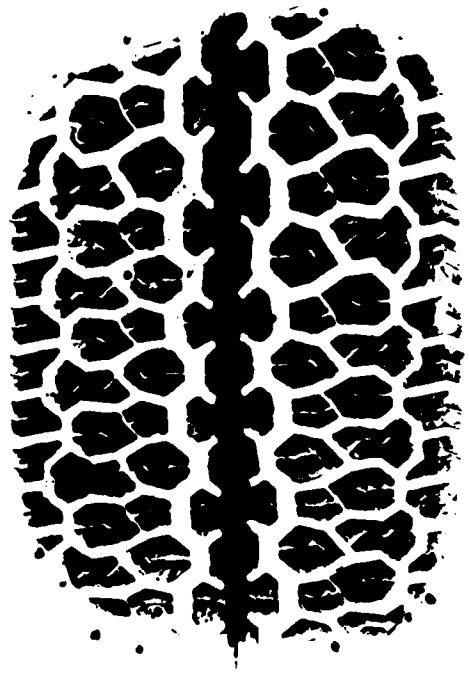


Figure 1. All-season design radial test tires (footprints).

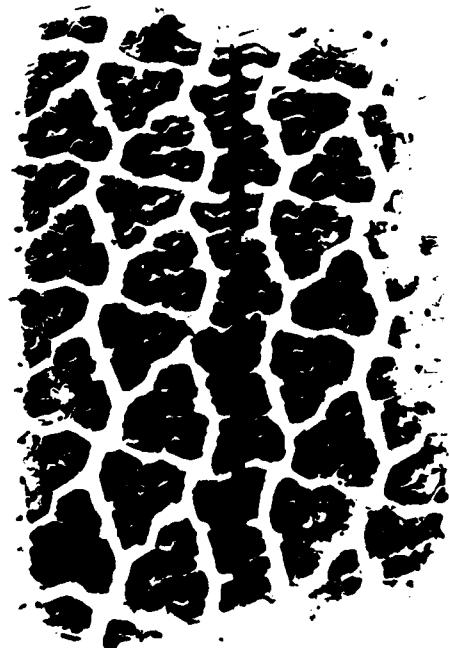
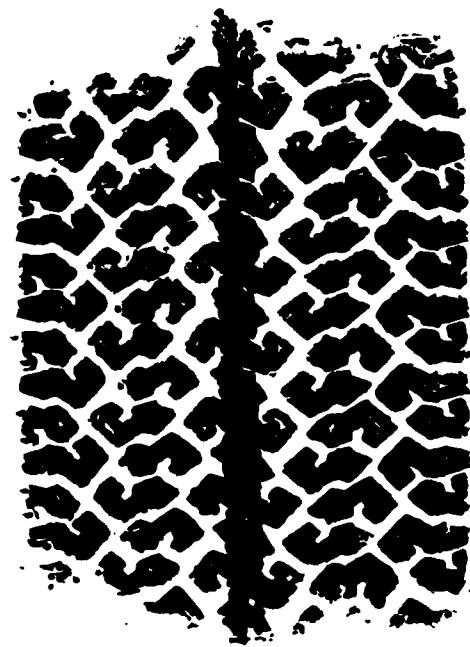
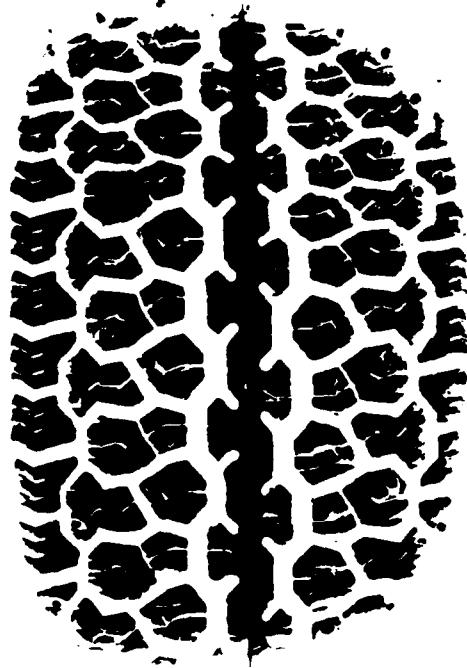


Figure 2. Microsiped configurations (footprints).

line present when the vehicle came to a complete stop. Braking tests were performed in opposite directions on alternate test runs on the ice sheet and the operator attempted to use a fresh lane on the ice for each run.

When approximately 10 good test runs (initial braking speed equal to  $32 \pm 0.3$  km/h ( $20 \pm 0.2$  mi/h)) were completed, a mean stopping distance and the standard deviation were calculated. Test runs that had stopping distances greater or less than 1.5 standard deviations from the mean were omitted, and additional test runs were made until at least 10 acceptable data points were available. A new mean and standard deviation were then calculated and used for analysis using the first 10 test runs that met the 1.5 standard deviation criterion.

### Results

For two of the all-season tire types (tires X and Y), in both microsiped and conventional conditions, braking tests were performed at several temperatures. Using a linear regression, temperature dependence was determined for the microsiped and conventional versions of the same two tires (Figure 3). Within experimental error, the difference in temperature effect between the microsiped and conventional versions of tire Y is negligible. A slightly greater difference is displayed by tire X; however, it

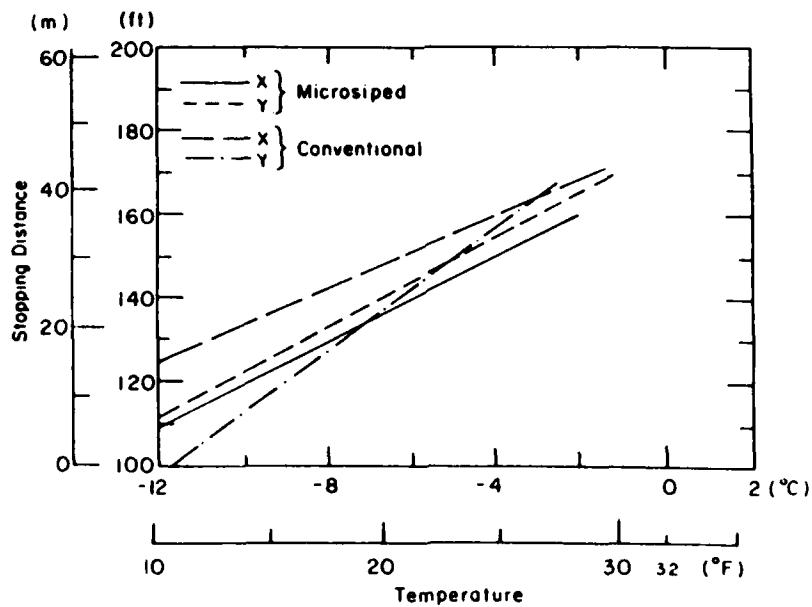


Figure 3. Stopping distance vs temperature for microsiped and conventional tires X and Y.

is still considered to be minor. This is not a surprising result since the temperature dependence of stopping distance on ice is a result of the temperature dependence of the adhesion between the tread compound and the ice. Microsiping does not effect the tread compound in any way, and thus is ineffectual in significantly altering the stopping distance/temperature relationship of the tire.

Both all-season tire types (tires X and Y) tested at various temperature showed a relatively strong temperature dependence on stopping distance. As is the case with most tires, but by no means all, as temperature decreased, the stopping distance also decreased. The stopping distance vs temperature relationship for the two tire types showed slopes of 4.3 and 7.2 (Figure 3), which correspond to a change in stopping distance of 1.3 and 2.2 m/ $^{\circ}$ C change in temperature (2.4 and 4.0 ft/ $^{\circ}$ F), respectively.

The results of the braking distance comparison for the four tire types, in microsiped and conventional versions, are shown in Figure 4. The comparative values of stopping distances shown are for a temperature of -5 $^{\circ}$ C (23 $^{\circ}$ F). For the tires tested at -5 $^{\circ}$ C (23 $^{\circ}$ F), each bar represents the average of all of the repetitions of each test set (10 stopping distance runs). The tires that were not tested directly at this temperature were tested at a minimum of one temperature above and one temperature below -5 $^{\circ}$ C (23 $^{\circ}$ F). The value shown in Figure 4 for these tires is taken from the regression performed on all of the data associated with the tire.

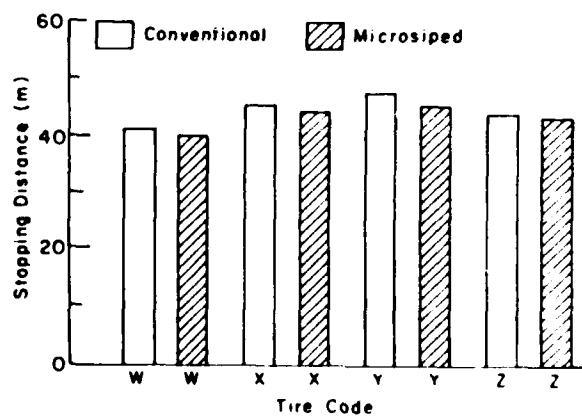


Figure 4. Braking distance comparison.

Table 1. Stopping distance comparison between micro-siped and conventional all-season tires.

Tire Code	Conventional m (ft)	Microsiped m (ft)
W	41.2 (135.3)	40.0 (131.1)
X	45.1 (148.1)	44.1 (144.6)
Y	47.5 (155.7)	45.3 (148.8)
Z	<u>43.9 (143.9)</u>	<u>43.4 (142.3)</u>
Ave.	44.4 (145.8)	43.2 (141.7)
St. Dev.	2.6 (8.5)	2.3 (7.6)

Table 1, which summarizes the stopping distances shown in Fig. 4, initially appears to indicate that notable changes in braking traction occur with the four types of tires tested. However, the differences between microsiped and conventional tire performance are well within the 1.5 standard deviations normally applied to vehicle performance data; this parameter was also used in bounding each stopping distance value obtained from the 10 test repetitions. In fact, the difference in braking performance between the two tire conditions is only one-half of a standard deviation, far too small to be considered meaningful for this kind of data.

These results are not surprising. Previous studies (Blaisdell, 1983b) indicate that traction on ice is principally governed by the adhesion between the ice surface and the tread compound of the tire. Traction with various types of aids that penetrate the ice surface is a different matter. Traction is then also a function of the shear strength of the ice; however, microsiping certainly does not fall into this category. Since the tractive forces developed at the contact patch are the result of adhesion, the effect of tread design, tread depth, or any other tread features on stopping distance is minimal. Unless microsiping is in some way able to increase the ice-adhesive property of the tread, it is difficult to see how slicing a tire's surface could improve stopping distances on ice.

It is perhaps significant to note the decrease in variation in the stopping distance with microsiped tires. Since the standard deviation recorded in Table 1 refers to the variation between tire types, it appears that microsiping acts to slightly diminish the differences in performance between various tires. Checking the raw stopping distance data, it can

also be seen that, for a particular tire type, variations in braking performance are diminished somewhat with microsiping for each individual tire.

## DRIVING TRACTION TESTS

### Test Area and Equipment

Driving traction tests were conducted on the same ice sheet as the braking tests and during the same one-week time period. These tests were conducted using the CRREL instrumented vehicle (Blaisdell, 1983a).

The test tires for the driving traction tests were identical to those for the braking tests (Figs. 1 and 2) except for their size, which was P205/75R15 rather than P155/80R13. In addition to the microsiped and conventional test tires, a P225/75R15 control tire (radial) was used to monitor changes in the ice surface. Inflation pressure was maintained at 220 kPa (32 lb/in.<sup>2</sup>) and the vertical load on the test tires varied between 5800 and 6200 N (1300 and 1400 lbf).

### Test Procedure

Traction tests were performed using the instrumented vehicle in front-wheel drive mode with the braked rear wheels providing hold-back. The rectangular ice sheet was used for the traction tests in the same manner as in the braking tests. During traction testing, vehicle speed was held constant at  $8 \pm 1$  km/h ( $5 \pm 0.6$  mi/h). The front, instrumented tires were accelerated through a range of slip speeds from 0 to 17 km/h (10.5 mi/h). (Slip velocity is defined as differential interface velocity, or the difference between vehicle and tire speeds.) As was done for the braking tests, an equal number of traction test runs were made in alternate directions on the ice in untracked lanes.

A sampling rate of 20 samples per second per channel was used for the traction tests. Six traction test runs were completed for each test tire set and the control tire. From these the average performance value was obtained. Both the right and left side tire performance were averaged, so actually 12 test runs were averaged. The time period during which these tests were performed, as was true for the braking tests, was chosen so that a fluctuation in air temperature of not more than  $2^{\circ}\text{C}$  ( $3.6^{\circ}\text{F}$ ) occurred.

The driving traction performance was determined using the MUA average method of analysis (Domeck, 1982). With this method, performance for each

test tire is determined by calculating the area under the tractive coefficient (tractive force divided by the vertical load) vs DIV (differential interface velocity) curve between the DIV rates of 1.6 and 25 km/h (1-5 mi/h) and then dividing by 23.4 (the difference between 1.6 and 25 km/h). This performance value, averaged for the six test repetitions, is then divided by the average MUA value determined for the control tire and expressed as a percent. In this way small fluctuations in the air or ice temperature during the course of testing were removed. In addition, this method allows tests run on different days at different temperatures to be directly compared or averaged.

### Results

Combining the data from several test days, with ice temperatures ranging from -3 to -8°C (26.5 to 17.5°F), in the manner reported above, comparative driving traction was determined (Figure 5). As was true for the braking traction data, it is immediately apparent that large differences in performance between microsiped and conventional tire types are not present. In two cases the microsiped tires appear to provide slightly better performance while the two other tires show exactly the opposite trend. As was the case with the braking data, however, the differences in average performance for each tire type are within one standard deviation of the test data for all of the tires except in one case (tire type X), where it is equal to 1.5 standard deviations. Therefore, considering as acceptable  $\pm 1.5$  standard deviations, the difference between the driving per-

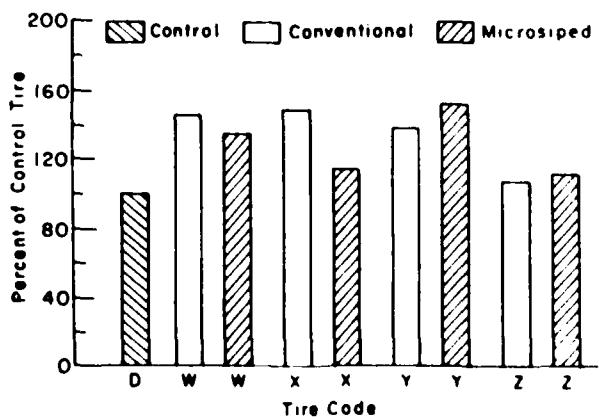


Figure 5. Driving traction comparison.

Table 2. Driving traction comparison between microsiped and conventional all-season tires (expressed as a percent of control tire performance).

Tire Code	Conventional	Microsiped
W	146	135
X	149	114
Y	138	152
Z	107	111
Control	<u>100</u>	<u>-</u>
Ave.	135 (not incl. control)	128
St. Dev.	19.2	19.2

formance of microsiped and conventional versions of a particular tire type is negligible.

When lumping the tire performance results together, it is also seen that a small (5%) difference exists between the microsiped and conventional tires and that, if anything, the unsiped tires are marginally better (Table 2). This difference in performance is well within one half of the standard deviation of the traction data for these different tires. It therefore appears that there is definitely no net gain in tractive ability when driving on ice with microsiped all-season tires. This can be explained by considering the quantities that contribute to traction. As was previously indicated, traction on ice with a non-penetrating driving element, as in this case with a microsiped and a conventional tire, is principally governed by the adhesion developed between the tread compound and the ice surface. Unless the microsiping alters the adhesive qualities of the tire tread or changes the ice surface, it would not be expected to significantly affect traction on ice.

## CONCLUSIONS

Microsiped tires, by comparison with conventional tires of the same all-season radial design, generally show no measurable improvement in stopping distance on ice for the tire types and temperatures tested in this study. The only measurable difference noted was the decreased variation in braking performance between various types by microsiping. The ice tempera-

ture-stopping distance trend of the tires was found to remain the same, and the magnitude of the change in stopping distance per unit change in temperature is approximately equal before and after microsiping.

It can be seen from the driving traction tests on microsiped and conventional all-season tires that very little difference in performance is present. If anything, the data suggest that a slight drop in driving traction levels might be expected by microsiping new all-season radial tires.

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